



SHILAP Revista de Lepidopterología

ISSN: 0300-5267

ISSN: 2340-4078

avives@orange.es

Sociedad Hispano-Luso-Americana de Lepidopterología
España

Efetov, K. A.; Kucherenko, E. E.; Tarmann, G. M.

**New synthetic sex attractants for the males of two endemic
Iberian Procrinae species (Lepidoptera: Zygaenidae)**

SHILAP Revista de Lepidopterología, vol. 47, no. 186, 2019, May-August, pp. 307-315

Sociedad Hispano-Luso-Americana de Lepidopterología
España

Available in: <https://www.redalyc.org/articulo.oa?id=45561111022>

- How to cite
- Complete issue
- More information about this article
- Journal's webpage in redalyc.org

redalyc.org

Scientific Information System Redalyc

Network of Scientific Journals from Latin America and the Caribbean, Spain and
Portugal

Project academic non-profit, developed under the open access initiative

New synthetic sex attractants for the males of two endemic Iberian Procridinae species (Lepidoptera: Zygaenidae)

K. A. Efetov, E. E. Kucherenko & G. M. Tarmann

Abstract

Sex attractants for *Rhagades (Wiegelia) predotae* (Naufock, 1930) and *Adscita (Tarmannita) bolivari* (Agenjo, 1937), two endemic Iberian Procridinae species (Lepidoptera: Zygaenidae), are reported for the first time. During fieldwork in Spain in 2017 and 2018, the males of *Rh. predotae* and *Rh. (Rhagades) pruni* ([Denis & Schiffermüller], 1775) were attracted to the lures with the substance “EFETOV-S-S-2” (S-enantiomer of 2-butyl 2-dodecenoate), while the males of *A. bolivari* reacted to “EFETOV-2” (a racemic mixture of R- and S-enantiomers). This result (together with our previous data) shows that (2S)-butyl 2-dodecenoate is likely to be a “generic” sex attractant for the males of the genus *Rhagades* Wallengren, 1863. We demonstrate that attractive lures may be a sensitive and efficient tool for monitoring the two rare Spanish species, viz. *Rh. predotae* and *Rh. pruni*.

KEY WORDS: Lepidoptera, Zygaenidae, Procridinae, *Rhagades predotae*, *Rhagades pruni*, *Adscita bolivari*, sex attractant, EFETOV-2, EFETOV-S-S-2, Spain.

Nuevo atrayente sintético sexual para los machos de dos especies ibéricas endémicas de Procridinae (Lepidoptera: Zygaenidae)

Resumen

Se indica por primera vez, un atrayente sexual para *Rhagades (Wiegelia) predotae* (Naufock, 1930) y *Adscita (Tarmannita) bolivari* (Agenjo, 1937), dos especies ibéricas endémicas de Procridinae (Lepidoptera: Zygaenidae). Durante el trabajo de campo en España en 2017 y 2018, los machos de *Rh. predotae* y *Rh. (Rhagades) pruni* ([Denis & Schiffermüller], 1775) fueron atraídos a los señuelos con la sustancia “EFETOV-S-S-2” (S-enantiómero de 2-butil 2-dodecenoato), mientras los machos de *A. bolivari* reaccionan frente a “EFETOV-2” (una mezcla racémica de R- y S-enantiómeros). Este resultado (con nuestros datos previos) indica que (2S)-butil 2-dodecenoato es, probablemente, un atrayente sexual para los machos del género *Rhagades* Wallengren, 1863. Demostramos que los señuelos atrayentes podrían ser una herramienta susceptible y eficiente para monitorear las dos especies singulares españolas, véase *Rh. predotae* y *Rh. pruni*.

PALABRAS CALVE: Lepidoptera, Zygaenidae, Procridinae, *Rhagades predotae*, *Rhagades pruni*, *Adscita bolivari*, atrayente sexual, EFETOV-2, EFETOV-S-S-2, España.

Introduction

The Iberian Peninsula is one of the richest European regions in animal species diversity (RAMOS *et al.*, 2001). 54% of the total species described for Europe and approximately 38% of the species assessed by the European Red List of Species are present in Spain (SÁNCHEZ *et al.*, 2013). According to the data of the International Union for Conservation of Nature (2018), the country is located in one of the 25 biodiversity hotspots in the world, thanks to its high rate of endemism.

Historically, the researchers have tended to focus on the study of sex pheromones of insect pests

rather than attractive molecules for protected and threatened species (OLEANDER *et al.*, 2015; RAZOV *et al.*, 2017; SUBCHEV *et al.*, 1998, 2009, 2012, 2013, 2016; WITZGALL *et al.*, 2010). However, pheromone-based monitoring methods can reveal rare and endangered species even with very low population density due to their sensitivity and species-selectivity. Pheromone lures and traps can detect and monitor the seasonal flight of such insects and provide a better understanding of their biology (LARSSON, 2016). Despite these obvious advantages, pheromones have been exploited for these purposes in very few cases in part because of the high cost and the difficulty of identifying them (MILLAR *et al.*, 2010; SVENSSON *et al.*, 2012). Synthetic sex attractants can successfully replace natural pheromones especially if they are expensive or unstable (EFETOV *et al.*, 2010, 2011, 2015b; SUBCHEV *et al.*, 2010; XU *et al.*, 2012). Additionally, field screening tests of sex attractants are generally simpler, more effective and less laborious than visual searches for a target species (EFETOV *et al.*, 2014b; RAY *et al.*, 2014).

Previous studies have reported the attractive properties of 2-butyl 2-dodecenoate (*R*- and *S*-enantiomers and a racemic mixture) produced in the Crimean Federal University. The species and sex specificity of the newly synthesized esters has been proved for Procridae moths in field observations undertaken in the Crimea, continental Russia, Austria, Greece, Italy, Tajikistan, Turkey, Japan, and some other countries (CAN CENGİZ *et al.*, 2018; EFETOV *et al.*, 2016a, 2016b, 2017, 2018; EFETOV & GORBUNOV, 2016). In 2017 and 2018, our field screening tests were carried out in Spain.

Large revisional work has been done on Palaearctic Procridae during the last years (EFETOV, 1992, 1996a, b, 1997a, b, 1998, 1999, 2001a, 2006, 2010; EFETOV *et al.*, 2014b; EFETOV & TARMANN, 1999, 2013a, b, 2014a, b, 2016a, b, 2017b; KEIL, 2014; MOLLET & TARMANN, 2007). Based on the recent classification, the Zygaenidae family includes five subfamilies: Inouelinae Efetov & Tarmann, 2017; Procridae Boisduval, 1828; Chalcosiinae Walker, 1865; Callizygaeninae Alberti, 1954; and Zygaeninae Latreille, 1809 (EFETOV, 2001b; EFETOV *et al.*, 2004, 2006, 2014a, 2015a; EFETOV & HAYASHI, 2008; EFETOV & KNYAZEV, 2014; EFETOV & SAVCHUK, 2009, 2013; EFETOV & TARMANN, 2012, 2017a; HOFMANN & TREMEWAN, 2017; KNYAZEV *et al.*, 2015a, b). The Zygaenidae fauna of Spain is represented by Procridae, Chalcosiinae, and Zygaeninae. Six Zygaenidae species are endemics of the Iberian Peninsula: *Rhagades (Wiegelia) predotae* (Naufok, 1930), *Adscita (Adscita) jordani* (Naufok, 1921), *A. (A.) schmidtii* (Naufok, 1933), *A. (Tarmannita) bolivari* (Agenjo, 1937), *Jordanita (Jordanita) vartianae* (Malicky, 1961) (subfamily Procridae), and *Zygaena (Agrumenia) ignifera* Korb, 1897 (subfamily Zygaeninae) (EFETOV, 2004; EFETOV & TARMANN, 2012).

Male specimens of Zygaenidae use chemical and visual signals for finding the females (EFETOV *et al.*, 2015b; NAZAROV & EFETOV, 1993). In the subfamily Procridae the majority of species has cryptic habitus and as a result chemical attraction is more important (EFETOV *et al.*, 2010, 2014c). Sex pheromones or sex attractants were unknown for any endemic Spanish species (El-SAYED, 2018; SUBCHEV, 2014). However, it was recently shown that (2*S*)-butyl 2-dodecenoate attracts the males of *Rhagades (Rhagades) pruni* ([Denis & Schiffermüller], 1775) in the Crimea and Italy (EFETOV *et al.*, 2016c, 2017), and *Rhagades (Wiegelia) amasina* (Herrich-Schäffer, 1851) in the Middle Anatolia Region of Turkey (CAN CENGİZ *et al.*, 2017; CAN *et al.*, 2018). We hypothesized that the males of the rare endemic Spanish species *Rh. predotae* also might come to lures or sticky traps with synthetic (2*S*)-butyl 2-dodecenoate. Thus, the objectives of the present work were: 1) to determine whether (2*S*)-butyl 2-dodecenoate is a sex attractant for the males of *Rh. predotae*; 2) to test 2-butyl 2-dodecenoate (the racemate and its enantiomers) as an attractant for other Spanish Procridae species including *Rh. pruni*, a very rare species on the Iberian Peninsula.

Materials and methods

Field experiments with synthetic sex attractants were undertaken in Spain by G. M. Tarmann in Barcelona Province from 13–20 June 2017 and by K. A. Efetov and G. M. Tarmann in Cuenca Province from 9–13 July 2018 (see Table 1 for locality information, Figs 1–6). We tested responses of Procridae

species to three attractants: EFETOV-2 (the racemate), EFETOV-S-2 (*R*-enantiomer), and EFETOV-S-S-2 (*S*-enantiomer) of 2 butyl 2-dodecenoate. The synthesis of the indicated ester was made according to the procedure published by EFETOV *et al.* (2014c).

Table 1.— A list of studied localities in Spain in 2017 and 2018 (Figs 1-6).

Number of locality	Description of the localities	GPS coordinates
Castilla-La Mancha, Cuenca Province		
I	vic. Huélamo, 1265 m (Fig. 1)	N 40° 15,385' / W 01° 45,920'
II	NE of Huélamo, 1228 m	N 40° 17,700' / W 01° 47,770'
III	NE of Huélamo, 1222 m (Fig. 2)	N 40° 17,706' / W 01° 47,866'
IV	NE of Huélamo, 1225 m (Figs 3-5)	N 40° 17,450' / W 01° 47,650'
V	S of Uña, 1184 m	N 40° 13,457' / W 01° 59,407'
VI	S of Tragacete, 1256 m	N 40° 20,174' / W 01° 49,570'
Catalonia, Barcelona Province		
VII	W of Alpens, 870 m (Fig. 6)	N 42° 07,767' / E 02° 05,050'

To prepare baits, rubber caps were impregnated with different types of attractants, fixed on cardboard rectangles and marked. A variety of methods were used to assess the attractiveness of the baits: Delta plastic sticky traps with lures hung on bushes or trees or cardboard rectangles with rubber caps placed on stones on the ground (Fig. 7) or attached to the hat of the researcher slowly crossing the biotope. Each method had its advantages and drawbacks. In the last two cases, the attracted specimens were collected by netting them near the rubber caps.

All specimens were determined by examination of the genitalia by K. A. Efetov and G. M. Tarmann.

Results and discussion

During our field trials in 2018 the attraction of two endemic Iberian Procridinae species to some of the exposed baits was recorded, viz. *Rh. predotae* and *A. bolivari*. In addition, the males of *Rh. pruni* were attracted in 2017. The list of attracted specimens, type of lures, and time of observation are provided below.

Rh. predotae (Naufock, 1930)

Locality III, near rubber caps with EFETOV-S-S-2, 1 ♂, 10-VII-2018, 20:38; locality III, near rubber caps with EFETOV-S-S-2, 1 ♂, 11-VII-2018, 11:30; locality III, near rubber caps with EFETOV-S-S-2, 3 ♂♂, 11-VII-2018, 20:40-20:47; locality III, near rubber caps with EFETOV-S-S-2, 4 ♂♂, 12-VII-2018, 20:20-20:30; locality IV, near rubber caps with EFETOV-S-S-2, 4 ♂♂, 13-VII-2018, 20:44-21:07.

A. bolivari (Agenjo, 1937)

Locality I, near rubber caps with EFETOV-2, 8 ♂♂, 9-VII-2018, 19:20-20:00; locality V, near trap with EFETOV-2, 1 ♂, 10-VII-2018, 14:00; locality II, near rubber caps with EFETOV-2, 5 ♂♂, 10-VII-2018, 20:00-20:20; locality III, near trap with EFETOV-2, 3 ♂♂, 11-VII-2018, 19:30-20:00; locality VI, near rubber caps with EFETOV-2, 1 ♂, 12-VII-2018, 12:30; locality IV, near rubber caps with EFETOV-2, 2 ♂♂, 13-VII-2018, 20:30.

Rh. pruni ([Denis & Schiffermüller], 1775)

Locality VII, near rubber caps with EFETOV-S-S-2, 2 ♂♂, 15-VI-2017, 11:35; locality VII, near rubber caps with EFETOV-S-S-2, 3 ♂♂, 19-VI-2017, 10:05-10:32.

Totally, 20 *A. bolivari* males were attracted to EFETOV-2, whereas 13 ♂♂ of *Rh. predotae* and 5

♂♂ of *Rh. pruni* came to lures with EFETOV-S-S-2. In the locality IV on 13th July 2018 three attractants were simultaneously placed on stones more than 10 m apart from each other. All the males of *Rh. predotae* were attracted only to lures EFETOV-S-S-2, while the males of *A. bolivari* were attracted to EFETOV-2. No specimens of any of the species approached the lure EFETOV-S-2 in this locality.

It is interesting that despite the fact that the traps with sticky layers were fixed to the branches of bushes at the altitude 1.0-1.5 m above the ground in almost all localities, we did not find any glued specimen of *Rh. predotae* and *A. bolivari* in the traps. All specimens were attracted only to rubber caps placed on the stones, fixed to the clothes or the hat of the collector.

Only male moths (Fig. 8) were captured indicating that these compounds act as a sex-specific attractants. Almost all males of *Rh. predotae* were attracted at evening twilight from 20:20-21:07 around the moment of sunset over the mountains. 18 flying males were additionally caught in locality IV without baits on 12 July also in the evening (21:00-21:35). It can thus be suggested that mating activity of this species connected with pheromone communication is at the end of the day. If we compare the time *Rh. predotae* and *A. bolivari* come to the attractants "EFETOV", we see that *Rh. predotae* males were attracted mainly in the evening at sunset, while the males of *A. bolivari* were active also during the day.

In this study we show that EFETOV-S-S-2 ((2S)-butyl 2-dodecenoate) is a sex attractant for the males of *Rh. predotae*. This is a very rare species of which the biology is insufficiently studied. *Rh. predotae* is only known from several specimens kept in museum collections (NAUMANN *et al.*, 1999). The adults are not nocturnal but visual searches for this species in their habitat and inspection of host-plants have been unsuccessful. Now, the application of this attractant-based method allows us to detect *Rh. predotae*.

Previously, it was shown that *Rh. pruni* (EFETOV *et al.*, 2016c, 2017) and *Rh. amasina* (CAN CENGİZ *et al.*, 2017; CAN *et al.*, 2018) were also attracted to EFETOV-S-S-2. Based on this knowledge G. M. Tarmann used the synthetic sex attractant EFETOV-S-S-2 for rediscovering this species in Spain on the southern side of the Pyrenees in 2017. *Rh. pruni* is a very rare species on the Iberian Peninsula and occurs only in the central and eastern Pyrenees in Spain. It reaches here its westernmost distribution in the Palaearctic Region. So far, only three male specimens from three localities were known from the southern side of the Pyrenees, all situated in the Barcelona Province. All other records from Spain are from localities in Valle de Arán, situated on the northern side of the Pyrenees. Therefore, the south-eastern slopes of the Pyrenees in the Catalanian provinces of Barcelona and Lérida were carefully screened by G. M. Tarmann using a rubber lure with EFETOV-S-S-2 on cardboard that was attached to his hat. Literally hundreds of bush-groups of *Prunus spinosa*, partly mixed with *Crataegus* and *Rubus*, the well-known preferred habitats of *Rh. pruni* in Spain, France, Italy and Central Europe, were examined for a whole week, but only in one single locality was the search successful (in locality VII where five males of *Rh. pruni* had been attracted to lures with EFETOV-S-S-2 in good weather conditions with cloudless skies). In conclusion one can say that the artificial attractant EFETOV-S-S-2 was definitely responsible for this rediscovery of *Rh. pruni* in the south-eastern Pyrenees in Spain (although the species was extremely rare in 2017) after more than a third of a century (last record known is from 1980).

Our results provide further support for the hypothesis outlined in the introduction of this paper that (2S)-butyl 2-dodecenoate is a "generic" sex attractant for males of different species of the genus *Rhagades* Wallengren, 1863. Pheromone structure can be conservative within closely related Procrinae species of this genus. A similar situation is known also for other insects (RAY *et al.*, 2014).

Conclusion

Sex attractants for two endemic Iberian Procrinae species, viz. *Rhagades* (*Wiegelia*) *predotae* and *Adscita* (*Tarmannita*) *bolivari*, were found for the first time. *Rh. predotae* males reacted to lures with (2S)-butyl 2-dodecenoate, while *A. bolivari* males were attracted to the racemate of 2-butyl 2-

dodecenoate. Synthetic (2S)-butyl 2-dodecenoate is a sensitive and effective tool for monitoring *Rh. predotae* and *Rh. pruni* populations.

Acknowledgments

We thank Dr. A. Vives Moreno (Spain) for his help in obtaining the relevant collecting permits for our field work in Spain into the Scientific Project of SHILAP. For help in preparing attractants, we are indebted to Dr M. Y. Baevsky and Mr A. I. Poddubov (Russia). We also thank Dr A. Spalding (Great Britain) for editing the English text.

BIBLIOGRAPHY

- CAN, F., EFETOV, K. A., KAYA, K., KUCHERENKO, E. E., ULAŞLI, B. & TARMANN, G. M., 2018.– Application of sex attractants for investigation of the Procridinae fauna (Zygaenidae) in the Middle Anatolia Region of Turkey, 22-23 pp.– In F. CAN & Z. OKYAR (eds). *XVI. International Symposium on Zygaenidae (İzmir, Turkey, 1-5 May 2018)*: I-VIII, 39 pp. MCU Press, İzmir.
- CAN CENGİZ, F., EFETOV, K. A., KAYA, K., KUCHERENKO, E. E., ULAŞLI, B. & TARMANN, G. M., 2017.– A study of Procridinae (Zygaenidae) species by new sex attractants in the Middle Anatolia Region of Turkey, 84 p.– In P. DRKENDA & B. DUČIĆ (eds). *Book of Abstracts of 28th International Scientific-Expert Conference of Agriculture and Food Industry (Sarajevo, Bosnia and Herzegovina, 27-29 September 2017)*: 167 pp. TMP, Sarajevo.
- CAN CENGİZ, F., EFETOV, K. A., KAYA, K., KUCHERENKO, E. E., OKYAR, Z. & TARMANN, G. M., 2018.– Zygaenidae (Lepidoptera) of Thrace Region of Turkey.– *Nota lepidopterologica*, **41**(1): 23-36.
- EFETOV, K. A., 1992.– On the systematic position of *Ino duskei* (Lepidoptera, Zygaenidae).– *Zoologicheskii Zhurnal*, **71**(4): 144-148.
- EFETOV, K. A., 1996a.– The description of the female of *Adscita* (Zygaenoprocris) *rjabovi* (Alberti, 1938) (Lepidoptera: Zygaenidae, Procridinae).– *Entomologist's Gazette*, **47**(1): 31-35.
- EFETOV, K. A., 1996b.– The description of the female of *Illiberis* (*Alterasvenia*) *yuennanensis* Alberti, 1951 (Lepidoptera: Zygaenidae, Procridinae).– *Entomologist's Gazette*, **47**(2): 111-113.
- EFETOV, K. A., 1997a.– Two new species of the genus *Artona* Walker, 1854 (Lepidoptera: Zygaenidae, Procridinae).– *Entomologist's Gazette*, **48**(3): 165-177.
- EFETOV, K. A., 1997b.– Three new species of the genus *Illiberis* Walker, 1854, from Taiwan and Vietnam (Lepidoptera: Zygaenidae, Procridinae).– *Entomologist's Gazette*, **48**(4): 231-244.
- EFETOV, K. A., 1998.– A revision of the genus *Goe* Hampson, [1893] (Lepidoptera: Zygaenidae, Procridinae), with descriptions of two new species.– *Entomologist's Gazette*, **49**(1): 49-62.
- EFETOV, K. A., 1999.– *Inouela* gen. n. from Japan and Taiwan (Lepidoptera: Zygaenidae, Chalcosiinae).– *Entomologist's Gazette*, **50**(2): 91-95.
- EFETOV, K. A., 2001a.– On the systematic position of *Zygaenoprocris* Hampson, 1900 (Lepidoptera: Zygaenidae, Procridinae) and the erection of two new subgenera.– *Entomologist's Gazette*, **52**(1): 41-48.
- EFETOV, K. A., 2001b.– An annotated check-list of Forester moths (Lepidoptera: Zygaenidae, Procridinae).– *Entomologist's Gazette*, **52**(3): 153-162.
- EFETOV, K. A., 2004.– *Forester and Burnet Moths* (Lepidoptera: Zygaenidae). *The genera Theresimima Strand, 1917, Rhagades Wallengren, 1863, Zygaenoprocris Hampson, 1900, Adscita Retzius, 1783, Jordanita Verity, 1946* (Procridinae), and *Zygaena Fabricius, 1775* (Zygaeninae): 272 pp. CSMU Press, Simferopol.
- EFETOV, K. A., 2006.– Nine new species of the genus *Chrysartona* Swinhoe, 1892 (Lepidoptera: Zygaenidae, Procridinae).– *Entomologist's Gazette*, **57**(1): 23-50.
- EFETOV, K. A., 2010.– *Illiberis* (*Hedina*) *louisi* sp. nov. (Lepidoptera: Zygaenidae, Procridinae) from China.– *Entomologist's Gazette*, **61**(4): 235-241.
- EFETOV, K. A., CAN, F., TOSHOVA, T. B. & SUBCHEV, M., 2010.– New sex attractant for *Jordanita anatolica* (Naufock) (Lepidoptera: Zygaenidae: Procridinae).– *Acta Zoologica Bulgarica*, **62**(2): 315-319.
- EFETOV, K. A. & GORBUNOV, O. G., 2016.– Attraction of the males of *Adscita statices* (Linnaeus, 1758) (Lepidoptera: Zygaenidae, Procridinae) by synthetic sex attractant in Moscow Region.– *Tavricheskii Mediko-biologicheskii Vestnik*, **19**(3): 40-46.

- EFETOV, K. A. & HAYASHI, E., 2008.— On the chaetotaxy of the first instar larva of *Artona martini* Efetov, 1997 (Lepidoptera: Zygaenidae, Procrinae, Artonini).— *Entomologist's Gazette*, **59**(2): 101-104.
- EFETOV, K. A., HOFMANN, A. & TARMANN, G. M., 2014b.— Application of two molecular approaches (use of sex attractants and DNA barcoding) allowed to rediscover *Zygaenoprocris eberti* (Alberti, 1968) (Lepidoptera, Zygaenidae, Procrinae), hitherto known only from the female holotype.— *Nota lepidopterologica*, **37**(2): 151-160.
- EFETOV, K. A., HOFMANN, A., TARMANN, G. M. & TREMEWAN, W. G., 2014a.— Taxonomic comments on the treatment of the Zygaenidae (Lepidoptera) in volume 3 of *Moths of Europe*, Zygaenids, Pyralids 1 and Brachodids (2012).— *Nota lepidopterologica*, **37**(2): 123-133.
- EFETOV, K. A., KOSHIO, C. & KUCHERENKO, E. E., 2018.— A new synthetic sex attractant for males of *Illiberis* (*Primilliberis*) *pruni* Dyar, 1905 (Lepidoptera: Zygaenidae, Procrinae).— *SHILAP Revista de lepidopterología*, **46**(182): 263-270.
- EFETOV, K. A. & KNYAZEV, S. A., 2014.— New records of *Jordanita* (*Roccia*) *volgensis* (Möschler, 1862) (Lepidoptera: Zygaenidae, Procrinae) from Siberia (Russia) and Ukraine.— *Entomologist's Gazette*, **65**(3): 175-178.
- EFETOV, K. A., KUCHERENKO, E. E. & DESSE, J.-M., 2016a.— Sex attractant for *Adscita* (*Procriterna*) *subtristis* and *Jordanita* (*Tremewania*) *splendens* (Lepidoptera: Zygaenidae, Procrinae).— *Crimean Journal of Experimental and Clinical Medicine*, **6**(2): 33-36.
- EFETOV, K. A., KUCHERENKO, E. E., PARSHKOVA, E. V. & TARMANN, G. M., 2016b.— 2-butyl 2-dodecenoate, a new sex attractant for *Jordanita* (*Tremewania*) *notata* (Zeller, 1847) and some other Procrinae species (Lepidoptera: Zygaenidae).— *SHILAP Revista de lepidopterología*, **44**(175): 519-527.
- EFETOV, K. A., KUCHERENKO, E. E. & TARMANN, G. M., 2016c.— New synthetic sex attractants for Zygaenidae, 14-15 pp.— In G. M. TARMANN, W. G. TREMEWAN & A. SPALDING (eds). *XV International Symposium on Zygaenidae (Mals/Malles, Südtirol/Alto Adige, Italy, 11-18 September 2016)*: I-XVIII, 46 pp. BGO Bürgergenossenschaft Obervinschgau, Mals/Malles.
- EFETOV, K. A., PARSHKOVA, E. V., BAEVSKY, M. Y. & PODDUBOV, A. I., 2014c.— Sec-butyl ester of dodecenoate: synthesis and attractive properties.— *Ukrainian Biochemical Journal*, **86**(6): 175-182.
- EFETOV, K. A., PARSHKOVA, E. V. & KOSHIO, C., 2004.— The karyotype of *Illiberis* (*Primilliberis*) *rotundata* Jordan, [1907] (Lepidoptera: Zygaenidae, Procrinae).— *Entomologist's Gazette*, **55**(3): 167-170.
- EFETOV, K. A., PARSHKOVA, E. V., TARASOVA, L. G. & TARMANN, G. M., 2015a.— The karyotypes of Procrinae (Lepidoptera: Zygaenidae), with the first record of the karyotype of *Pollanisus commoni* Tarmann, 2004, a representative of the tribe Artonini.— *Entomologist's Gazette*, **66**(2): 121-125.
- EFETOV, K. A. & SAVCHUK, V. V., 2009.— The first record of *Jordanita* (*Roccia*) *volgensis* (Möschler, 1862) (Lepidoptera: Zygaenidae, Procrinae) from the Crimea.— *Entomologist's Gazette*, **60**(3): 155-158.
- EFETOV, K. A. & SAVCHUK, V. V., 2013.— Newly discovered morphs of *Zygaena dorycnii* Ochsenheimer, 1808 (Lepidoptera: Zygaenidae, Zygaeninae) in the Crimea, Ukraine.— *Entomologist's Gazette*, **64**(2): 111-115.
- EFETOV, K. A., SUBCHEV, M. A., TOSHOVA, T. B. & KISELEV, V. M., 2011.— Attraction of *Zygaenoprocris taftana* (Alberti, 1939) and *Jordanita horni* (Alberti, 1937) (Lepidoptera: Zygaenidae, Procrinae) by synthetic sex pheromones in Armenia.— *Entomologist's Gazette*, **62**(2): 113-121.
- EFETOV, K. A. & TARMANN, G. M., 1999.— On the systematic position of *Procris fusca* Leech, [1889] (Lepidoptera: Zygaenidae, Procrinae).— *Entomologist's Gazette*, **50**(3): 163-168.
- EFETOV, K. A. & TARMANN, G. M., 2012.— *A Checklist of the Palaearctic Procrinae (Lepidoptera: Zygaenidae)*: 108 pp. CSMU Press, Simferopol - Innsbruck.
- EFETOV, K. A. & TARMANN, G. M., 2013a.— *Illiberis* (*Alterasvenia*) *cernyi* sp. nov. (Lepidoptera: Zygaenidae, Procrinae) from northern Thailand.— *Entomologist's Gazette*, **64**(1): 33-39.
- EFETOV, K. A. & TARMANN, G. M., 2013b.— *Chrysartona* (*Chrysartonna*) *mineti* sp. nov. (Lepidoptera: Zygaenidae, Procrinae) from northern Vietnam.— *Entomologist's Gazette*, **64**(3): 197-206.
- EFETOV, K. A. & TARMANN, G. M., 2014a.— *Illiberis* (*Alterasvenia*) *banmauka* sp. nov. (Lepidoptera: Zygaenidae, Procrinae) from China and Myanmar.— *Entomologist's Gazette*, **65**(1): 62-70.
- EFETOV, K. A. & TARMANN, G. M., 2014b.— A new European species, *Adscita dujardini* sp. nov. (Lepidoptera: Zygaenidae, Procrinae) confirmed by DNA analysis.— *Entomologist's Gazette*, **65**(3): 179-200.
- EFETOV, K. A. & TARMANN, G. M., 2016a.— *Pseudophacusa multidentata* Efetov & Tarmann, a new genus and species of Procrini from Myanmar, China and Laos (Lepidoptera: Zygaenidae, Procrinae).— *SHILAP Revista de lepidopterología*, **44**(173): 81-89.

- EFETOV, K. A. & TARMANN, G. M., 2016b.– A new *Illiberis* species: *I. (Alterasvenia) kislowskyi* (Lepidoptera: Zygaenidae, Procridinae) from Myanmar.– *Entomologist's Gazette*, **67**(2): 137-142.
- EFETOV, K. A. & TARMANN, G. M., 2017a.– The hypothetical ground plan of the Zygaenidae, with a review of the possible autapomorphies of the Procridinae and the description of the Inouelinae subfam. nov.– *Journal of the Lepidopterists' Society*, **71**(1): 20-49.
- EFETOV, K. A. & TARMANN, G. M., 2017b.– *Thibetana keili* Efetov & Tarmann, a new species of the genus *Thibetana* Efetov & Tarmann, 1995, from Tibet (Lepidoptera: Zygaenidae, Procridinae, Artonini).– *SHILAP Revista de lepidopterología*, **45**(180): 581-587.
- EFETOV, K. A., TARMANN, G. M., HAYASHI, E. & PARSHKOVA, E. V., 2006.– New data on the chaetotaxy of the first instar larvae of Procridini and Artonini (Lepidoptera: Zygaenidae, Procridinae).– *Entomologist's Gazette*, **57**(4): 229-233.
- EFETOV, K. A., TARMANN, G. M. & KUCHERENKO, E. E., 2017.– Catches of Procridinae (Zygaenidae) by new synthetic sex attractants in Italy, Austria and Greece, 58 p.– In M. ŠAŠIĆ, J. ROTA & I. MIHOČI (eds). *Book of Abstracts of the 20th European Congress of Lepidopterology (Podgora, Croatia, 24-30 April 2017)*: 122 pp. Croatian Natural History Museum, Zagreb.
- EFETOV, K. A., TARMANN, G. M., TOSHOVA, T. B. & SUBCHEV, M. A., 2015b.– Enantiomers of 2-butyl 7Z-dodecenoate are sex attractants for males of *Adscita mannii* (Lederer, 1853), *A. geryon* (Hübner, 1813), and *Jordanita notata* (Zeller, 1847) (Lepidoptera: Zygaenidae, Procridinae) in Italy.– *Nota lepidopterologica*, **38**(2): 161-169.
- EL-SAYED, A. M., 2018.– *The Pherobase: database of pheromones and semiochemicals*. Available from <http://www.pherobase.com> (accessed 22th December 2018).
- HOFMANN, A. F. & TREMEWAN, W. G., 2017.– *The Natural History of Burnet Moths (Zygaena Fabricius, 1775) (Lepidoptera: Zygaenidae). Part 1*: 631 pp. Museum Witt, Munich.
- INTERNATIONAL UNION FOR CONSERVATION OF NATURE, 2018.– Available from <http://www.iucn.org/regions/europe/resources/country-focus/spain> (accessed 22th December 2018).
- KEIL, T., 2014.– Die Widderchen des Iran. Biologie und Verbreitung Lepidoptera, Zygaenidae.– *Entomologische Nachrichten und Berichte*, **17**: 1-462.
- KNYAZEV, S. A., EFETOV, K. A. & PONOMARYOV, K. B., 2015a.– Zygaenidae (Lepidoptera) from Omsk Region.– *Zoologicheskii Zhurnal*, **94**(11): 1297-1302.
- KNYAZEV, S. A., EFETOV, K. A. & PONOMARYOV, K. B., 2015b.– Zygaenidae (Lepidoptera) of Omsk Province.– *Entomological Review*, **95**(8): 1106-1111.
- LARSSON, M. C., 2016.– Pheromones and other semiochemicals for monitoring rare and endangered species.– *Journal of Chemical Ecology*, **42**(9): 853-868.
- MILLAR, J. G., MCELFRESH, J. S., ROMERO, C., VILA, M., MARI-MENA, N. & LOPEZ-VAAMONDE, C., 2010.– Identification of the sex pheromone of a protected species, the Spanish moon moth *Graellsia isabellae* (Lepidoptera: Saturniidae).– *Journal of Chemical Ecology*, **36**(9): 923-932.
- MOLLET, B. & TARMANN, G. M., 2007.– Two new species of *Zygaenoprocris* Hampson, 1900 (Lepidoptera: Zygaenidae, Procridinae) from Iran.– *Entomologist's Gazette*, **58**(1): 69-84.
- NAUMANN, C. M., TARMANN, G. M. & TREMEWAN, W. G., 1999.– *The Western Palaearctic Zygaenidae (Lepidoptera)*: 304 pp. Apollo Book, Stenstrup.
- NAZAROV, V. V. & EFETOV, K. A., 1993.– On the role of Zygaenidae (Lepidoptera) in pollination of *Anacamptis pyramidalis* (Orchidaceae).– *Zoologicheskii Zhurnal*, **72**(10): 54-67.
- OLEANDER, A., THACKERY, D. & BURMAN, J., 2015.– The effect of exposure to synthetic pheromone lures on male *Zygaena filipendulae* mating behaviour: implications for monitoring species of conservation interest.– *Journal of Insect Conservation*, **19**(3): 539-546.
- RAMOS, M. A., LOBO, J. M. & ESTEBAN, M., 2001.– Ten years inventorying the Iberian fauna: results and perspectives.– *Biodiversity and Conservation*, **10**: 19-28.
- RAY, A. M., ARNOLD, R. A., SWIFT, I., SCHAPKER, P. A., MCCANN, S., MARSHALL, C. J., MCELFRESH, J. S. & MILLAR, J. G., 2014.– (R)-desmolactone is a sex pheromone or sex attractant for the endangered valley elderberry longhorn beetle *Desmocerus californicus dimorphus* and several congeners (Cerambycidae: Lepturinae).– *PLoS ONE*, **9**(12): 1-18.
- RAZOV, J., EFETOV, K. A., FRANIN, K., TOSHOVA, T. B. & SUBCHEV, M. A., 2017.– The application of sex pheromone traps for recording the Procridinae fauna (Lepidoptera: Zygaenidae) in Croatia.– *Entomologist's Gazette*, **68**(1): 49-53.

- SÁNCHEZ, S., DEL CARPIO, A. P., NIETO, A. & BILZ, M., 2013.— *Spain's Biodiversity at Risk*: 8 pp. European Union Representative Office, Brussels.
- SUBCHEV, M., 2014.— Sex pheromone communication in the family Zygaenidae (Insecta: Lepidoptera): a review.— *Acta Zoologica Bulgarica*, **66**(2): 147-157.
- SUBCHEV, M., EFETOV, K. A., TOSHOVA, T., PARSHKOVA, E. V., TÓTH, M. & FRANCKE, W., 2010.— New sex attractants for species of the zygaenid subfamily Procrinae (Lepidoptera: Zygaenidae).— *Entomologia Generalis*, **32**(4): 243-250.
- SUBCHEV, M. A., EFETOV, K. A., TOSHOVA, T. B. & KOSHIO, C., 2016.— Sex pheromones as isolating mechanisms in two closely related *Illiberis* species - *I. (Primilliberis) rotundata* Jordan, 1907, and *I. (P.) pruni* Dyar, 1905 (Lepidoptera: Zygaenidae, Procrinae).— *Entomologist's Gazette*, **67**(1): 51-57.
- SUBCHEV, M., HARIZANOV, A., FRANCKE, W., FRANKE, S., PLASS, E., RECKZIEGEL, A., SCHRÖDER, F., PICKETT, J. A., WADHAMS, L. J. & WOODCOCK, C. M., 1998, erratum, 1999.— Sex pheromone of female vine bud moth, *Theresimima ampelophaga* comprises (2S)-butyl (7Z)-tetradecenoate.— *Journal of Chemical Ecology*, **24**(7): 1141-1151; **25**(5): 1203: i.e. corrected to (2R)-butyl (7Z)-tetradecenoate.
- SUBCHEV, M. A., KOSHIO, C., TOSHOVA, T. B. & EFETOV, K. A., 2012.— *Illiberis (Primilliberis) rotundata* Jordan (Lepidoptera: Zygaenidae: Procrinae) male sex attractant: Optimization and use for seasonal monitoring.— *Entomological Science*, **15**: 137-139.
- SUBCHEV, M., KOSHIO, C., TOSHOVA, T., EFETOV, K. A. & FRANCKE, W., 2013.— (2R)-butyl (7Z)-dodecenoate, a main sex pheromone component of *Illiberis (Primilliberis) pruni* Dyar (Lepidoptera: Zygaenidae: Procrinae)?.— *Acta Zoologica Bulgarica*, **65**(3): 391-396.
- SUBCHEV, M., TOSHOVA, T., KOSHIO, C., FRANKE, S., TRÖGER, A., TWELE, R., FRANCKE, W., PICKETT, J. A., WADHAMS, L. J. & WOODCOCK, C. M., 2009.— Identification and biological activity of sex pheromone components from females of the plum moth *Illiberis rotundata* Jordan (Lepidoptera: Zygaenidae: Procrinae).— *Chemoecology*, **19**: 47-54.
- SVENSSON, G. P., LIEDTKE, C., HEDENSTRÖM, E., BREISTEIN, P., BÅNG, J. & LARSSON, M. C., 2012.— Chemical ecology and insect conservation: optimising pheromone-based monitoring of the threatened saproxylic click beetle *Elater ferrugineus*.— *Journal of Insect Conservation*, **16**(4): 549-555.
- XU, P., GARCZYNSKI, S. F., ATUNGULU, E., SYED, Z., CHOO, Y.-M., VIDAL, D. M., ZITELLI, C. H. L. & LEAL, W. S., 2012.— Moth sex pheromone receptors and deceitful parapheromones.— *PLoS ONE*, **7**(7): 1-9.
- WITZGALL, P., KIRSCH, P. & CORK, A., 2010.— Sex pheromones and their impact on pest management.— *Journal of Chemical Ecology*, **36**(1): 80-100.

*K. A. E.

V. I. Vernadsky Crimean Federal University
RU-295051 Simferopol (Crimea)
RUSSIA / RUSSIA
E-mail: efetov.konst@gmail.com

E. E. K.

V. I. Vernadsky Crimean Federal University
RU-295051 Simferopol (Crimea)
RUSSIA / RUSSIA
E-mail: shysh1981@mail.ru

G. M. T.

Sammlungs und Forschungszentrum der Tiroler Landesmuseen
Krajnc-Straße, 1
A-6060 Hall
AUSTRIA / AUSTRIA
E-mail: g.tarmann@tiroler-landesmuseen.at

*Autor para la correspondencia / Corresponding author

(Recibido para publicación / Received for publication 29-I-2019)

(Revisado y aceptado / Revised and accepted 3-III-2019)

(Publicado / Published 30-VI-2019)

